points, due to the rigidity of some regions. Hence, an iterative method is used to individuate the plastic and rigid regions in successive steps, thereby, solving the optimization problem. Indeed, the combination of a mesh-free technique with the limit analysis principles leads to a stable upper bound solution for the cohesive soil problem under plane strain condition, in which there is no need for mesh in the traditional sense. Based on the derived formulation, a computer code has been developed, and the accuracy and efficiency of the proposed method is demonstrated by solving some examples at the end of the paper.

Key Words: Mesh-free method, cohesive soil.

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Abstract
Most dye substances are used in production processes and cause serious environmental pollution when discharged into the environment. Acid orange 7 is one of them, which has been studied in this research.
Acid orange 7 containing wastewater is resistant to aerobic degradation and, under anaerobic conditions, can be reduced to potentially carcinogenic aromatic amines. Physical processes have difficulty in complete destruction of dye pollutants.
Applications of both the slurry process and immobilized nano technology systems have recently been studied. Nano material agglomeration, light penetration in wastewater and the separation of nano materials from effluent are the most important disadvantages of the slurry process.
The purpose of this study is to propose a new suitable treatment method. This method consists of pretreatment of dye wastewater with ozonation, undertaking the immobilized-suspended photocatalytic process as the final treatment.
In the immobilized-suspended photocatalytic process, nano TiO2 were coated on submerged media. The coated media was characterized by Scanning Electron Microscopy (SEM) and Energy- Dispersive X-ray microanalysis (EDX) techniques.
The result has shown that COD removal efficiency decreased with a decrease in ozone injection rate, an increase in initial concentration, an increase in pH, a decrease in the number of media (nano TiO2 concentration) and a decrease in power of the light source. An experimental design, based on the Taguchi method, was applied to assess the effects of several operating parameters, including dye concentration, TiO2 concentration, pH, light source power, and ozone injection rate, on the energy consumption of the treatment. Based on experimental design data, optimum conditions were achieved at 50 mg/L of initial dye concentration, pH of 3, ozone injection rate at 1.2 gram per hour, 128 mg/L of nano TiO_2 (media number equal to 30) and 120 Watt UV-A light source. Under these conditions, dye removal was completed after 135 minutes. Then, in the photocatalytic process, 89% of COD was removed over 4 days using 30 media (128 mg/L), with 120 Watt light source.

Key Words: Ozone, TiO_2, Photocatalyst, Acid orange 7, Taguchi, Dye removal, COD.

UPPER BOUND LIMIT ANALYSIS IN COHESIVE SOILS USING A MESH-FREE TECHNIQUE

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Abstract
A novel approach is developed for computing the upper bound limit load of soil mechanic problems in cohesive soils under plane strain condition. In this regard, the cohesive soil is considered as a rigid-plastic material which obeys the Von-Mises failure criterion. By implementation of the associated flow rule and the normality law, the stress at the yield state is related to the plastic strain increment. A mesh-free technique, called the radial point interpolation method, is adopted to express the strain increment field in terms of nodal velocities. Hence, both stress and plastic strain increment can be attributed to the nodal velocities, as well as the rate of internal energy dissipation. The discretized internal energy dissipation power, in conjunction with the incompressibility condition for the Von-Mises yield criterion and the conditions related to external loads, leads to a mathematical optimization problem which should be solved by an iterative technique. The technique consists of the establishment of the Lagrange functional and the formation of a linear system of equations by differentiation, with respect to the unknown nodal velocities and the Lagrange multipliers. By solution of the system of equations, the unknown nodal velocities and the Lagrange multipliers can be found. The deficiency of the proposed technique is that there is no guarantee regarding the differentiability of the Lagrange functional at all

strut model is the most popular, thanks to its practicality and fair accuracy. During an earthquake, forces are applied both in-plane and out-of-plane of the infill wall. Nevertheless, this simultaneous effect is ignored in most proposed models (including the strut model). Thus, this research is an attempt to scrutinize the behavior of structures under such a simultaneous effect.
In this research, first by micro modeling of the components of an infill wall, such as brick and interface elements, a one story, one bay model of an infill wall is made and subjected to numerical analysis. For this purpose, after comparing analytical results with experimental data and verification of the analytical model, the simultaneous effect of in-plane and out-of-plane loads is investigated. It shows that the in-plane damage has a significant effect on the out-of-plane stiffness and capacity of the infill wall. Furthermore, after careful studies on effective parameters in the behavior of the out-of-plane infill wall, it has been proven that the subject needs more in-depth study. The result of the research reveals that the simultaneous effect of the in-plane and out-of-plane forces has little to do with the in-plane capacity of the infill wall, but significantly reduces its stiffness and out-of-plane strength.

Key Words: Masonry infill wall, micro modeling, in plane-out of plane interaction, numerical analysis.

PROPOSING A NEW CABLE BRACING TO RETROFIT STEEL FRAMES

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Abstract
Bracing increases frame stiffness and reduces lateral displacement, due to transverse forces, but reduces frame ductility in comparison with moment resistant frames. A cable is known as a flexible element that can only undergo tension forces and has no compression strength. Using tension only elements within the bracing system of structures has created the idea of using cables as part of the lateral bracing system.
In the present research, a new cable bracing is proposed. Different moment resistant frames with and without bracing, together with the proposed bracing, were analyzed and compared. Under the lateral load effect, the moment resistant frame shows the most displacement, compared to the same frame equipped with bracing. By adding the x-bracing cables to the moment resistant frame, displacements are reduced considerably, depending on the size of the cable diameter, due to additional stiffness by the cables. Adding a square plate in the intersection of the x-bracing cables (proposed bracing) show that the displacements are reduced compared with x-bracing cables, although the displacements were less than those obtained from the moment resistant frame. The results also showed that using x- bracing cables as a continuous form, gave more displacements compared to x- bracing cables used at each frame cell. By adding a square plate in the intersection of the x-bracing cables, the displacements are increased, while displacements are reduced by increasing cable diameter.
In frames braced with cables, including the one proposed, increasing cable diameter causes an increase in cable axial load.
Finally, the results show that the behavior of the proposed bracing is somehow between the behavior of the x-braced and the moment resistant frames. By choosing different cable diameter and a square shaped plate for the proposed bracing, the results tend towards either the x-bracing or the moment resistant frame. Only one of the two braces in the x-bracing cables acts under tension; while all cables are under tension in the proposed bracing.

Key Words: Cable bracing, moment resistant frame, cable, non-linear static analysis, retrofitting.

EFFECT OF OZONATION PRETREATMENT ON IMMOBILIZED- SUSPENDED PHOTOCATALYTIC PROCESS IN DYE WASTEWATER TREATMENT AND DETERMINATION OF ITS OPTIMUM CONDITION

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ANALYSIS FOR SPECIAL MOMENT RESISTING FRAMES WITH SHEAR WALLS

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Abstract

In this paper, the effect of the deterioration behavior of hysteretic loops in nonlinear static analyses (pushover) on special concrete moment-resisting frames with shear walls has been studied. One of the shortages in pushover analysis is that it approximately considers the effects of deterioration pertaining to hysteretic loops for structural elements. To evaluate this effect, it is necessary to perform nonlinear static and dynamic analyses and compare the results. To this end, six different planar frames, each one part of a three-dimensional design structure, have been modeled. All structures are the same in plane and different in height. After conducting the pushover analyses for defining the target displacement, dynamic analyses are also performed, considering the two different employed behavioral models. Because OPENSEES software has various behavioral characteristics for steel and concrete, and also has the ability to suitably model structural elements, it was used for performing the nonlinear static and dynamic analyses. In order to find the capacity curve of the structure, the displacement of the control node and the shear force of the base level were calculated using this software. For accurate calculation of the target displacement and bilinear idealization of the capacity curve, a computer program was developed in the Matlab environment to determine the target displacement, strength ratio (R) and etc.

The employed material models are reinforcing steel material, concrete02 and hysteretic material. Deterioration behavior, as well as non-degrading behavior, is considered in nonlinear dynamic analyses. For modeling the structural elements, stresses and strains for each designed section are considered, with respect to confinement effects. The required backbone curve includes cracking point, yielding point and ultimate stress point, which are all derived from USC-RC software, and, of course, by considering element cross section, arrangement, number and size of reinforcing bars. Also, twelve ground motion records, which are scaled to 0.35g hazard level, have been used in time history analyses.

Finally, maximum displacement amounts derived from inelastic dynamic analyses for 0.35g hazard level are compared with the amounts of target displacements, which express the maximum displacement of the structure under design earthquake, and we consider the effects of different parameters, such as deterioration, with the coefficient, c2. Results show that by increasing the height of the frame, the variance between frame displacement, with both deteriorating and non-degrading behavior, will be decreased, so that the effect of the deterioration behavior could be neglected in the target displacement calculation for high-rise frames.

Key Words: Deterioration behavior, nonlinear static analysis, nonlinear dynamic analysis, special moment resisting frame, shear wall.

SEISMIC BEHAVIOR OF MASONRY INFILL WALLS IN RC FRAMES UNDER SIMULTANEOUS IN-PLANE AND OUT-OF-PLANE LOADS

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Abstract

For structural and architectural reasons, masonry infill walls are widely used in building construction. Civil engineers usually consider infill walls as architectural elements and ignore them in structural analysis and design. However, it has been proven that infill walls change the behavior of structures, and, therefore, it would not be correct to ignore their significance in the analysis and design of a structure. The last few years have seen an increase in research into the subject, and many different models that consider the role of infill walls in analyses, have been proposed. Among all proposed models, the

loading surface diameter) and vertical spacing of the two geocell layers, and h, in terms of h/D, in the foundation bed, were studied. Assessment of performance is investigated for one and two layers of geocell, whereas the used mass of geocell material is kept constant. For example, the experiment reinforced by two layers of geocell with H/D=0.225 has exactly the same mass of geocell compared with the experiment reinforced by one thicker layer of geocell reinforcement with H/D=0.45. The results show that the settlement under repeated loads is the large portion of the settlement that occurs during the first few cycles of loading and unloading compared to the total settlement recorded after all cycles. The optimum vertical spacing of geocell layers was found to be approximately 0.2 times the loading plate diameter (i.e., h/D=0.2). For one layer reinforcement, with an increase in the height of the geocell, the settlement of the loading plate decreases. The reinforced bed with two layers of geocell has more efficiency than one layer of geocell in reducing the surface settlement, whereas the same mass of geocell was used in the foundation bed. For example, the maximum settlements of loading plate for the two layers of geocell-reinforced soil bed with H/D=0.225 (h/D= 0.2) and for one layer of geocell-reinforced soil bed with H/D=0.45, at the end of loading, are 36% and 28% of the loading plate diameter, respectively.

Key Words: Geocell-reinforced sand, layered geocell, soil surface settlement, repeated load.

ATTENUATION RELATIONSHIPS FOR PEAK GROUND ACCELERATION IN THE IRANIAN PLATEAU USING GENE EXPRESSION PROGRAMMING (GEP)

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Abstract

This paper proposes attenuation relationships for peak ground acceleration (PGA) for horizontal and vertical components of earthquakes in the Iranian plateau. So far, many attenuation relationships have been presented based on several parameters. Attenuation relationships were, initially, simple functions of a few variables, but gradually became more and more sophisticated over time as the number and accuracy of records and the use of computer calculations increased. Ground motion during an earthquake depends mainly on source mechanics, magnitude, local geology, surface topography, source to site distance and the dynamic properties of the material propagation.

However, in this research, because of lack of information in Iran, only the magnitude of the earthquake, the distance between the earthquake source and the location and the ground type are used as important factors. Surface wave magnitude (Ms) is used in this research, since the occurred and reported earthquakes in Iran are shallow. Furthermore, hypocentral distance is considered as the distance between the earthquake source and the location.

The Iranian plateau is divided into two seismic zones: Alborz-central Iran and Zagros. From a ground-type point of view, the records of each region can be subdivided into two parts. Therefore, all records are grouped into four categories: 1) Alborz and central Iran-rock ground type, 2) Alborz and central Iran-soil ground type, 3) Zagros-rock ground type, and 4) Zagros-soil ground type. In this regard, a majority of available catalogs relating to 490 seismic events in Iran have been gathered, out of which, 954 records are used. These include 493 records related to Alborz and central Iran and the rest associated with the Zagros region. These records comprise earthquakes with a surface wave magnitude greater, or equal to, 4, with a hypocentral distance greater than 5 km (and often less than 200 km).

To obtain the attenuation relationships for peak ground acceleration, a Gene Expression Programming (GEP) algorithm is used instead of the conventional constant regression model. The model is extracted smartly as a continuous period function. The results show a consistency with a high proportionality coefficient among the observed and anticipated results.

Key Words: Attenuation relationship, GEP, PGA, Iran, rock, soil.

INVESTIGATION OF DETERIORATION BEHAVIOR OF HYSTERETIC LOOPS IN NONLINEAR STATIC

200 ppm, $40gr/m^2$ of nano TiO_2, light intensity of 90 watts and 0.064 gr/L $NaIO_4$, respectively. At the same time, 62.91 and 66.19 percent removal efficiency was observed for $UV/TiO_2/NaBrO_3$ and $UV/NaBrO_3$ or initial dye concentrations of 100ppm and 0.045 gr/L $NaBrO_3$. This means that $NaIO_4$ is a stronger oxidant in comparison to $NaBrO_3$.

Key Words: Light intensity, concentration, dye direct blue 71, pH.

EFFECT OF SUPPLEMENTAL DAMPING ON SEISMIC RESPONSE OF ISOLATED STRUCTURES UNDER NEAR & FAR FIELD EARTHQUAKES

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Abstract

Seismic isolation as a passive control method of structures and an innovative approach in resistant seismic design reduces significantly the responses of structural system induced by strong ground motions. The performance of these systems in near fault (NF) ground motions with large pulses is different from far fault (FF) ground motions. It is shown that the effects of near field earthquake with large velocity pulses can bring the seismic isolation devices to critical working conditions. To overcome this problem the application of viscous damper is represented as an approach to improve the performance of these systems in near field earthquakes.

In the present paper, by modeling six base isolated structures, the seismic responses has been studied under near field and far field earthquakes. The isolators were modeled by using a mathematical model depicted by bi-linear hysteretic behavior. Nonlinear time history analyses were performed using finite element software of ABAQUS to study the influence of different values of supplemental damping (5%-40%) on the responses of base isolated structures. The variation of floor absolute acceleration, bearing displacement and storey drift for different values of supplemental damping under near field and far field earthquakes was studied. The influence of supplemental damping on the responses of isolated structures were studied under the variation of important system parameters such as superstructure flexibility, period of frames and number of storey of base isolated structures. The results showed that, generally, by increasing the damping ratio, responses of structures including the maximum floor acceleration and maximum floor relative displacements increased under near field earthquakes. But maximum floor relative displacements decreased under far field earthquakes. It was observed that base displacement response decreased by increasing damping ratio under near field and far field earthquakes. This reduction under near field earthquakes is greater than far field earthquakes. Also by increasing the supplemental damping under near field and far field earthquakes, the maximum story acceleration increased.

Key Words: Seismic isolation; Near Field; Damping; Subgrade; ABAQUS.

EXPERIMENTAL STUDY OF LAYERED GEOCELL REINFORCED BED SUBJECTED TO REPEATED LOAD

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Abstract

This paper describes a series of laboratory tests performed on geocell reinforced soil beds, with one and two layers of geocell and different heights of geocell under repeated loads (loading, unloading and re-loading), to simulate vehicle traffic loads. A soil surface settlement up to 20000 load repetitions was recorded, until its value became stable or failure occurred due to excessive settlement. The influence of the height of geocell layers, H, in terms of H/D (H: the height of geocell layers, and D: the

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Abstract

At several last decades, the researchers have suggested various methods for strengthening of reinforced concrete beam- column connections that each of them has deficiencies and advantages. Each proposed method has particular advantages such as increasing capacity, stiffness, material costs, construction process cost and professional labor, so due to new required property of deficient structure, one of those method can be applied. This paper presents an experimental investigation of strengthening effects on the external corner weak (with low strength concrete and low height of beam) reinforced concrete (RC) beam-column connections by suggestion method of steel elements (steel prop & curb) subject to cyclic loading. Three half scale RC beam-column connections with low strength concrete were prepared and casted, including of two un-strengthened reference connections with different height of beam (low and standard height), and another with low height of beam that was strengthened by suggested system of one direction steel prop and curb that then every sample were subjected to cyclic loading.

The experimental results and observations indicated that by 25% reduction of height of connection beam, caused to reduction in stiffness, increasing the lateral displacement of beam of connection and also reduction 25%, 33% and 26% in ductility, bear capacity and energy absorption respectively. Also, it was determined that the suggested system of strengthening, by increasing strength and decreasing stiffness degradation, and raising the energy absorption of RC weak beam- column connection, can minimize the damages due to cyclic loading in the beam to column joint and panel zone. It can cause to development behavior of weak RC connection, as the performance of weak RC connection was upgraded to limit of behavior of connection with standard beam. Therefore, this suggested system with any different sizes and angles, corresponding to the required strength and stiffness can be easily applicable for any deficient RC beam-column connection in RC frames.

Key Words: Beam-column connection, strengthening, steel prop, steel curb, RC frame.

COMPARING THE CAPABILITY OF $NAIO_4$ AND $NABRO_3$ OXIDANTS ON IMPROVING UV/TIO_2 PHOTOCATALYTIC PROCESS IN REMOVAL OF DIRECT BLUE 71 DYE

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Abstract

Synthetic dyes are widely used in many industries, such as, textile dyeing, leather tanning, plastic and paper. In general, more than 40 percent of initial dye mass remains in the dye bath, which means that it is highly contaminated. Azo dyes, the largest class of synthetic dyes, are distinguished by containing one or more azo groups (-N=N-) that are bounded to the aromatic rings. They not only give color to water but also have mutagenesis and carcinogenesis potential and induce the production of toxic byproducts. They are difficult to remove from wastewater using common physical, chemical and biological treatment methods, and, therefore, it is essential to look for appropriate techniques for treatment of these kinds of pollutant to reduce their environmental impact. Recently, application of advanced oxidation methods, such as photo catalytic reactions, for removing toxic and non-bio-degradable pollutants from drinking water and textile wastewater have been expanded. It is based on the generation of hydroxyl radicals (0OH) with great oxidizing potential that can quickly and non-selectively oxidize a wide spectrum of diverse organic dyes. This method does not have the problem of residuals and, also, can be used at room temperature and under atmospheric pressure.

The main objective of this study is to examine the effect of adding oxidants, $NaIO_4$ and $NaBrO_3$, in a photocatalytic process using TiO_2 nanoparticles immobilized on concrete substrate using UV radiation in different systems for the removal of direct blue 71 dyes. In order to determine the optimum conditions, initial dye concentration, pH, intensity of UV-C radiation, and oxidants dosage during testing, were investigated. After 25 minutes, 39.4, 79.54 and 84.75 percent removal efficiency was obtained for three systems of UV/TiO_2, $UV/NaIO_4$ and UV/$TiO_2/NaIO_4$, in initial dye concentrations of

groups. Beam elements are used in this study to connect each of the piles, and these connections are rigid. Further, due to the influence of the superstructure on the behavior of pile foundations, this effect is modeled in the analyses. To account for the soil stiffness acting on the pile shaft, normal and shear springs are accommodated in the interface of the soil and pile elements. To evaluate the data for the parameters of the interface elements, a 2D finite difference analysis has been performed to calculate the required parameters of the interface elements at various depths. To model sand and structural members, Mohr-Coulomb and elastic models are employed, respectively. For dynamic analyses, attention has been paid to quiet boundaries, free fields, and wave propagation in the soil medium. Four different arrangements have been considered for pile cap. Results of analyses show that a increase or decrease in cap stiffness does not necessarily change extreme induced forces (i.e., maximum shear force, bending moment and lateral displacement) along the piles in the group. However, for a given mass of the system, there is a range of stiffness for the pile group that has maximum effect on induced internal forces and lateral displacements. For a flexible pile cap, the induced bending moments and shear forces along the individual piles depend on the location of the piles in the group.

Key Words: Pile cap stiffness, dynamic analysis, soil-pile-structure interaction, 3D finite difference analysis.

AN INVESTIGATION INTO THE MECHANICAL PROPERTIES OF GRANULAR MATERIALS IN AN INTERFACE WITH ASPHALTIC CONCRETE

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Abstract

Asphaltic concrete has been used as a waterproofing core for embankment dams since 1948. Worldwide, the large majority of the embankment dam central core is made of clay. However, as clay is increasingly difficult to find at new construction sites, asphalt concrete has been used as a replacement core material. Core made of clay has some further disadvantages, such as; low shear strength, compressibility, long construction time, requiring higher amounts of material, and accurate controls during construction, etc. The advantages of using asphalt concrete are; less sensitivity to weather conditions, less width of core, the healing behavior of bitumen and high shear strength etc. In this application, granular materials are used around the asphaltic concrete as a filter, which creates complicated behavior at the interface and which needs to be researched by experiment and modeling. This paper describes the experimental work and the results of investigating the mechanical behavior of the interface between aggregates and asphaltic concrete. A small scale shear strength test has been used in this study, in which the shear surface is considered as the interface. The effect of bitumen penetration grade, moisture, density and angularity of aggregates on the shear strength parameters at different levels of vertical stresses and constant shear rate was studied. Asphalt concrete specimens were cut in square shapes (10شه10شه2.5cm) from cylindrical specimen compacted by a modified marshal compaction method. The results show that the shear strength parameters increase with increasing the density and vertical stress level. It is also shown that the shear parameters decrease with increasing moisture content in the interface. The penetration grade of bitumen does not have a significant effect on the parameters. It is also demonstrated that the ratio of interaction between the aggregate and asphalt concrete decreases in a certain range of variation.

Key Words: Asphalt concrete, sand material, interface, interaction, small scale direct shear test.

EXPERIMENTAL INVESTIGATION OF THE CYCLIC BEHAVIOUR OF RC CONNECTIONS STRENGTHENED WITH STEEL PROP AND CURB

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(II) Fluid flow in the crack and (III) Crack propagation due to fluid motion.
The results of numerical analysis by the provided code, which is examined on a classic hydraulic fracturing problem, exhibit decreasing fluid pressure and increasing crack openings at the borehole well, as the crack length progresses. These results are in line with the results obtained by the KGD analytical solution. Also, it was observed that the width of the crack opening should be increased to enhance the exploitation of hydrocarbon products. In order to reach this goal, the fluid viscosity and/or injection rate of the fluid should be increased.

Key Words: Hydraulic fracturing, oil reservoirs, extended finite element method.

BARRAGE PARAMETRIC ANALYSIS USING GENETIC ALGORITHM

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Abstract
The, so called, barrage diverts water from rivers and steers it to the main channel. This requires careful design and analysis of hydraulic, hydrological and structural engineering. Barrage construction cost is not constant and, for a variety of different soil and hydrological conditions, the cost varies. The depth of sheet-piles/cutoffs and the length and thickness of the floor are the parameters influencing the cost of barrages. When a sheet-pile depth is changed, floor length and uplift force change over the floor, which has an impact on floor thickness and makes the cost of the barrage change to a non-linear form. In the present study, an optimization model is presented to fix the basic barrage parameters, which are depth of sheet piles/cutoffs, and length, and the thickness of the floor is based on Khosla's theory for subsurface flow. Basic barrage parameters need to be optimized, so that barrage costs for filling, excavation, dewatering, concreting, sheet-piling and driving will be minimal, provided that the output of the hydraulic gradient does not exceed the permissible hydraulic gradient. Therefore, note that the objective function is nonlinear and the multivariate and nonlinear constraint of the problem is optimized using the genetic algorithm. The algorithm, judiciously searches for optimal design within the problem space.
Matlab software is a complete toolbox in the field of genetic algorithms, therefore, all procedures relating to the genetic algorithm is performed in Matlab software. Results of parametric analysis using the genetic algorithm show that a barrage founded on sand would cost less than a barrage on silt or silty clay for the same head, and the depth of the upstream sheet pile is sensitive neither to the value of permissible exit gradient nor to the seepage head.

Key Words: Barrage, hydraulic exit gradient, sheet-pile, Khosla's theory, genetic algorithms, Matlab.

EFFECT OF PILE CAP STIFFNESS ON THE BEHAVIOR OF PILE GROUP UNDER EARTHQUAKE LOADING

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Abstract
Piles are often placed closely in a group to serve as the foundation of specific structure, such as offshore platforms, bridge structures and tall buildings. Pile groups should be capable of withstanding significant lateral loads induced by seismic excitations, winds, waves, and current loads. The main objective of this research is to investigate the effect of the stiffness of the pile cap on the behavior of piles embedded in sand under dynamic loads, by means of the 3D finite difference method. Previous research shows that pile cap stiffness, connection type of pile-cap and soil-pile-structure interaction play important roles in the behavior of laterally loaded pile

Abstracts of Papers in English

NUMERICAL MODELING OF HYDRAULIC FRACTURING IN OIL RESERVOIRS WITH EXTENDED FINITE ELEMENT METHOD

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Abstract

Due to more than one hundred years of oil and gas extraction, most reservoirs, especially those with high permeability, are gradually running out. Hence, the tendency is towards utilization of reservoirs with low permeability. Also, after continuous extraction of hydrocarbon products, natural reservoir pressure is reduced, cracks are closed and the production of the reservoir is reduced. It is, therefore, necessary to undertake additional methods in order to enhance the capacity of such reservoirs; hydraulic fracturing is such a method, which is popularly applied to 50% of oil and 70% of gas wells in North America.

In hydraulic fracturing, the fluid with pressure more than the in-situ stress of the region is injected into the place of the well that had been isolated by packers. When the fluid pressure exceeds the in-situ stress, hydraulic fracturing will occur.

One numerical method recently developed for simulation of hydraulic fracturing is the extended finite element method (XFEM). In this method, the nodes surrounding the cracks are enriched through special functions. Accordingly, for such nodes, the degrees of freedom are increased, which results in greater displacement around each crack. In this research, a XFEM code was developed to simulate the hydraulic fracturing problem.

The code provides three interaction processes: (I) Mechanical deformation due to fluid pressure on the crack,